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PROSPECTUS

In this, our fourth issue of *Business Briefs* (completing the first year of publication) we have again cast around among a wide variety of books and articles for some unusual approaches to current problems.

The lead article is drawn from Horace D. Gilbert's book, *Miniaturization*, which Reinhold Publishing Company has scheduled for publication this summer. Mr. Gilbert is President of Miniature Precision Bearings, Inc., in Keene, New Hampshire.

Sir Geoffrey Vickers, whose analysis of judgment comes from *The Manager*, a leading British journal, was an army officer in World War I, partner of a law firm in the years following, Deputy Director General of the Ministry of Economic Warfare in World War II, and a member of the National Coal Board in the years following. In addition he has lectured widely, written many essays, served as an officer of numerous private organizations, and been knighted. His paper is The Sixth Elbourne Memorial Lecture given last November to The British Institute of Management.

Merle H. Miller is a member of the Indianapolis law firm of Ross, McCord, Ice & Miller. His article comes from an address at the Nineteenth Annual Institute on Federal Taxation sponsored by New York University. The papers at the meeting have been edited by Henry Sellin and published this year by Matthew Bender and Company, Albany, New York.

Patrick J. McGovern, author of the article on computer conversation, is Assistant Editor of *Computers and Automation*, published in Newtonville, Massachusetts. His paper is based on a graduate thesis he wrote last year at Massachusetts Institute of Technology. The middle sections of the analysis are fairly technical, but you can get the gist of the argument from the first and last sections.

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DAVID W. EWING, *Editor*

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Topics covered: *manufacturing*
research and development
new products
quality control

Reading time: *13 minutes*

THE BIG BUSINESS OF MINIATURIZATION

By Horace D. Gilbert

There was a time when the term "American industry" was synonymous with "bigness." Recently, however, there has been a recognition that this interpretation is not precisely accurate. Many branches of American industry are thinking in terms of "smallness"; that is, the development of ever smaller components and finished products which are maintaining if not increasing efficiency and reliability. The successful large-scale development of such miniature components and finished products, in answer to the demands of modern science in business and the armed forces, has resulted in the comparatively new and dynamic field of miniaturization.

At the present time, miniature parts have made it possible for the United States to deliver into space man-made satellites which, although lighter in weight than Russian satellites, are superior in communicating achievement. Miniaturization is responsible for the ever-increasing capa-

city, efficiency, and economy of electronic computers for business, military, and scientific purposes. Miniaturization may aid medicine by making possible the development of more efficient tools for the surgeon and the diagnostician. With the development of transistor radios, miniature cameras, small tape recorders, and other devices for home and office, the consumer market for miniaturized products has just begun. A commercially practicable portable television set is already being market evaluated. In all fields, the growing interest in and demand for miniature products offers a golden opportunity to manufacturers. Evidence of the growth of this new science in the United States as well as throughout the whole world has prompted some responsible observers to refer to it as the "second industrial revolution."

Although the history of miniaturization dates back only to 1948, with the development of the transistor which replaced, for the first time, the bulky, hot, fragile vacuum tube so important in electronic devices, a fascination with miniaturized craft and art work has gripped mankind for centuries. Both Oriental and Western sculptors have done work so minute that it could be seen in all detail only under magnification. Portraits have been painted with brushes made of a single sable hair. Many people are familiar with the work of hobby ship-builders who long ago learned how to mount an inch-long cannon that would load and fire. Watchmakers have been practicing what is essentially miniaturization since the 13th century. In fact, tiny ball bearings small enough to replace the jeweled workings in a watch ultimately became vital components in the successful development of the famous Norden Bombsight during World War II.

Since 1948, however, interest in miniaturization has been scientific rather than artistic. The growth of miniaturization during the past 12 years has been so rapid that even the term itself has been modified to keep pace with developments. The terms subminiaturization, micro-miniaturization, and ultraminiaturization vary in meaning from company to company depending on the industry. The general term "miniaturization," however, includes all degrees of shrinking implied by these newly coined words.

IN DEFENSE

There is no doubt that modern miniaturization has received its greatest impetus from the national defense program. It has been estimated that anywhere from 50 to 80% of all miniaturization production today is designed either directly or indirectly for defense. Lt. Gen. Arthur G. Trudeau, Chief of Research and Development, Department of the Army, recently said: "Reduced size and weight and power requirements are factors that are becoming more and more important in the development of new weapons systems and equipment. . . . Every pound we can save in the weight of missiles by miniaturization means greater range and more economical use of fuel, and in certain applications, higher payloads, and to the Army and Marines, who man-pack the bulk of their battlefield weapons and equipment, the implications of a ten to one weight reduction are important in the extreme."

The complexity and multiplicity of modern weapons of warfare make miniaturization a matter of necessity for survival. For instance, a standard radio pack used by American Armed Forces in World War II weighed 40 pounds. Today the pack weighs 15 pounds, and it is expected that by 1965 the pack will be down to a mere 5 pounds. Other figures are even more impressive. A United States Army radio replay multiplexer, which allows several messages to be sent simultaneously, weighed 1,200 pounds during the Korean War. It is believed that by 1965 it will weigh 3 pounds.

A 1930 destroyer carried about 350 electronic components. A new destroyer carries about 350,000. This additional equipment can be accommodated only by a reduction in size.

In regard to military applications, miniaturization receives its widest acceptance in the missile field. If the weight of a missile's equipment is reduced by one pound, its fuel load can be reduced by 100 pounds. The Pioneer V satellite launched around the sun in the summer of 1960 was propelled by a Thor-Able vehicle with a thrust of 165,000 pounds. The aluminum sun satellite weighed only 94.8 pounds — including a small retrorocket and an instrument payload of only 9.2 pounds. Tactical missiles carrying an explosive as the payload are even more of a problem. They must carry with them navigational and radio equipment, plus the hardware necessary for operating the rocket.

Professor John Simpson, a University of Chicago physicist who designed much of the equipment aboard Pioneer V, has stated that the United States has been able to compete with Soviet rockets only because of miniaturization. He has said: "We don't need big rockets. We have the ability to do sophisticated experiments with minimum weight."

IN INDUSTRY

The impetus given to miniaturization by national defense needs has pushed this new science into many peacetime applications. Improvements in electronic computers call for widespread development of miniaturized components. Through miniaturization of mag-

netic memory storage elements it is expected that eventually it will be possible to construct memories of colossal capacity in small spaces. A recent advertisement for a computer manufacturing company asked: "Computers that fit in a briefcase?" and went on to state: "The progress in miniaturization of electronic components now going on may make it possible to shrink a computer so that it will take no more space than a briefcase."

To match the ingenuity of tiny electronic components, new ways of building circuits have been contrived. Bulky metal chassis, long leads, and solder globs have been practically eliminated. Conductors and resistors are now photographically printed onto an insulating background. By means of a vacuum-deposited method thin metallic films are evaporated onto insulating material. Recently, Bell Laboratories succeeded in "sputtering" an entire circuit by first laying a thin film of tantalum in an intricate pattern on a ceramic base to form the connectors. Progress in microcircuitry and molectronics is continuing rapidly.

Miniaturization in electronics is also resulting in a trend toward a new, more efficient, less costly way of servicing equipment. As equipment becomes more complex, we may anticipate an increased interest in multiple component duplicate plug-in units for replacement purposes. This would eliminate the need for finding and training high-priced service personnel.

Indications are that a growing demand for new miniaturized components will be made to keep pace with the growing concept of automated factories. To keep the controls from becoming larger than the machines, miniaturization of components must be highly developed. The controlling devices would consist of both pneumatic and hydraulic as well as electronic equipment.

It is important to emphasize that although miniaturization has been practiced most widely and most spectacularly in the electronics industry, miniaturization of mechanical as well as electrical parts constitutes an important segment of miniaturization manufacturing. Miniature ball bearings, for instance, which are scarcely larger than the period at the end of this sentence, are used in gyroscopes, automatic pilots, electro cardiographs, anemometers, synchros, servos, and high-speed dental handpieces.

FOR THE CONSUMER

In the consumer field, miniaturization promises to open up vast new markets; so far, however, manufacturers have only begun to tap the great potential that exists. Hearing aids, portable transistor radios, and hi-fidelity units have appeared; for a long time there has been the promise of truly portable TV. Most people are familiar with the small d-c motors in such toys as self-powered autos, whales that spout, and outboard motors that speed in the bathtub. General Electric, Cleveland, has developed a 150-watt bulb only 2.25 inches by 0.5 inch which should eventually find great consumer acceptance. Now there are hearing aids available no larger than a thumbnail which fit inside the ear or inside the hollow frame of a pair of glasses. There are tape recorders no larger than a kitchen matchbox. Dictating equipment has been made so small that transistorized battery-operated units can be carried in a briefcase. The market for these aids to the businessman may conceivably be as great as was that for the typewriter many years ago.

One of the deterrents to greater exploitation of the consumer market has been manufacturing costs. Unfortunately, the cost of miniaturization is usually inversely proportional to size. Thus there is a negligible mass market for consumer products which are reduced to half size if such a reduction means having to sell the unit at two or three times its former cost. With the rapid increase in know-how, however, it should be safe to predict that miniaturization will have a firm hold on the consumer market in the very near future.

IN SCIENCE

In the field of scientific investigation, particularly in medicine, miniaturization offers great promise. Imagine, for instance, a TV system, powered by tiny batteries, small enough to be swallowed, which could transmit a picture of the inside of a patient's stomach. Such a system has not yet been developed, but other types of devices following this general direction are available. An ingenious instrument has been built which takes samples of the lining of the gastrointestinal tract without necessitating a surgical operation. This device is simply a long tube, with a mechanical biopsy instrument at the end, which is passed orally into the stomach or the intestine. More exciting perhaps is the development of an ingestible capsule designed to sample intraluminal contents. When triggered by heat supplied by an externally energized coil its mechanism takes a sample of internal fluids.

Also available at the present time are tiny radio pills; capsule FM transducer-transmitters that are swallowed to broadcast information about the intestines; transmitters attached to the teeth for studies of night grinding; tiny probes that record the pulse, blood pressure, respiration, and temperature of astronauts.

In time the surgeon can expect to rely more and

more on miniature instruments. Already there is an electronic heart catheter. A tiny instrument mounted in the tip of the catheter is inserted into the heart through a vein in the arm; the surgeon is thus able to hear valve sounds from inside the heart. Heart surgeons have also succeeded in attaching miniature electronic devices to the heart to supply a "beat" when the natural timing mechanism does not function properly. It may soon be possible for people prone to cardiac trouble to maintain a 24-hour watch over their hearts. A miniature microphone, no bigger than a grain of rice, would be the core of the system. Any deviation from normal would cause an automatic signal to be broadcast by means of a mechanism no larger than a cigarette package. This signal would be received by either the individual or his nurse or doctor, who could then take suitable action.

Now familiar to almost everyone is the much publicized 250,000-plus-revolutions-per-minute air turbine dental drill which cuts so much faster and less painfully than the old mechanical types. These new drills could not operate without miniature ball bearings. Similar bearings are used in devices which save oil fields all over the world. An air-borne magnetometer containing many miniature bearings is trailed behind a flying aircraft to measure the magnetism of the earth. This new prospecting technique accomplishes in hours what formerly took months.

MINIATURIZATION AND THE MANUFACTURER

It is clear that in all market areas today — military, industrial, consumer, and scientific — miniaturization is only on the bottom step of a fast-rising escalator. The climb, however, is not without obstacles. The businessman contemplating a step toward miniaturization might find many problems which he would not encounter were he producing and marketing products of conventional size. Before making any definite decision, the prospective manufacturer of a miniaturized product should be thoroughly familiar with the kinds of problems he will face — seemingly minor problems such as training employees; major problems such as building an entirely new plant to eliminate vibration and temperature variation, and above all, to maintain high standards of cleanliness.

The experienced businessman entering the miniaturization field for the first time will be astonished at the cost of his investment in production machinery and parts. Much of the machinery is non-standard and frequently requires the purchase of specially designed parts at a higher cost with extended delivery and run-in dates. In some cases he may have to build a substantial part of his own production machinery, and since parts suppliers may not be able to meet requirements of size, weight, performance, or accuracy, he may be forced to make parts that other manufacturers would ordinarily buy off the shelf. Hence capital investment per worker may be unusually high.

Even the cost of raw materials for miniature products may be higher than the cost of ordinary raw materials. Miniature gyroscopes, for example, must be able to withstand severe missile-type environments. The materials that go into these components must obviously be of the highest quality. Special vacuum-melt steel is used in miniature ball bearings because it is free from inclusions, much cleaner, and of uniform quality, but the price is $5.67 a pound. In comparison, cold-rolled steel sells at approximately 24 cents a pound. Out of an annual 30 tons of stainless steel, chrome steel, and beryllium copper, 24 tons is ground and chipped into dust — waste — in the production of precision miniature ball bearings. Then too, the special materials needed for bearing components present many procurement problems since they are purchased in small quantities and must meet very exacting specifications. In fact, suppliers must be found who will make shipments by the pound rather than by the ton.

NEED FOR RESEARCH AND TRAINING

A manufacturer planning to deal in miniaturized products should consider the fact that technology, both in regard to design and production, is advancing so rapidly that a new company can barely catch up if it starts from scratch. In addition, individual orders are not likely to be large; rarely are there the long, profitable runs in miniaturization processes that were characteristic of older technologies.

In order to compete at all with the rapidly advancing technology, extensive research programs are essential. Such programs call for trained experimental metallurgists, mechanical engineers, physicists, mathematicians, and other experts not only to solve current problems but also to anticipate problems so that should they arise, solutions might be available. Such programs are costly, and a small company may have to allocate 10% of its sales for the work.

Capable physicists, mathematicians, and other experts are not likely to be familiar with the special problems of miniaturization at first. Practically all companies must train their own experts. Companies frequently set up their own schools of miniaturization; scientists and technicians divide their hours between the factory and the classroom, and are paid for the time spent in each. Even production workers must receive careful training. In most cases, prospective employees are given a series of tests — manual dexter-

ity, visual, and sometimes psychological aptitude tests — to determine their fitness for this kind of work.

IMPORTANCE OF QUALITY CONTROL

Smallness, together with ever-increasing demands for thoroughly dependable performance, creates increasingly difficult problems. Dr. Charles S. Draper, Director of the Instrumentation Laboratory at MIT, recently told the American Association for the Advancement of Science: "One mile may be taken as a typical uncertainty limit for useful inertial reference systems. The allowable drift rate corresponds to one minute of arc per hour. To meet this, the deviation of the center of mass must average less than one-tenth of one microinch."

Such tolerances were at one time impossible. Today they are even surpassed. To guarantee that all components will measure up to the rigorous demands of customers dealing in miniaturization, quality control becomes an essential part of the manufacturing process. Constant testing, however, is costly. For instance, out of every 100 transistors used by Lockheed for its tiny new nine-pound missile and satellite TV, only 7 to 10 pass the tests; the remainder are discarded. In general, inspection and quality control costs average 20% of manufacturing costs, and in some cases run as high as 30%.

In the production of miniature ball bearings at MPB, final assembly is carried out in a room sealed off from the rest of the plant. The air is filtered to remove particles down to 2 microns of an inch. Women workers dressed in special lint-free nylon coats and caps enter the room through a double door airlock. A positive air pressure which is maintained in the room prevents any dust from entering when the parts go through a window airlock. In this atmosphere, in a constant temperature of 68-70°F, under 200-foot candle soft light, finished bearings are washed, assembled, washed again, gauged, tested for performance, washed, lubricated, and then packaged either in sealed vials or hermetically-sealed plastic strips, like pills. Finger cots or gloves must be worn by employees handling miniature components to prevent them from being corroded by perspiration. Most of the techniques employed in this operation including methods of testing, and the equipment, lubricating oils, packaging vials, and pouches used, were all developed over a long period of time and at considerable expense to the company itself.

The manufacturer of miniature parts might reasonably expect that these precautions would prevent customers' complaints; it is frequently necessary, however, for the manufacturer to teach customers how to handle miniature parts. Many companies conduct series of one-week training courses to better acquaint their customers with precision miniature parts.

ADVANTAGES IN FIELD

Despite the problems, any manufacturer willing to take on the challenge will find certain advantages in the field of miniaturization. Most important, profits can be higher. In this fast-growing business it is not unheard of for a company to see annual sales multiplied 25 times in 10 years, with growth continuing at a "leveled-off" 25% per year.

The need for miniaturized products for national defense has been spoken of earlier, as well as the substantial sales volume in the computer, automation, and instrumentation fields, dentistry, medicine, and communication. The really high-volume high-profit market would seem ultimately to be in tiny devices or portable products for consumer use. It should be kept in mind that there is a golden opportunity for the manufacturer who can find some part of a miniature product — a resistor, gear, linkage, valve — which is not shrinking as fast as its related parts. The manufacturer who can make an economical miniature version of the needed part will have no difficulty finding customers. For the company just entering the field this approach is certainly easier than trying to produce a completely miniaturized piece of equipment. Selling to a small number of original equipment manufacturers is easier than attempting to open up a new finished-product consumer market.

RECENT TRENDS

One of the tasks of any manufacturer looking for miniaturization markets is to explore new developments and trends in the field. This is not easy since the picture changes daily, and very few corporations list their breakdown in sales in terms of standard versus miniaturized products. One indication of the trend, however, is the number of entries made in the annual Miniaturization Awards competition. Looking at the entries over a period of several years, one is struck most emphatically by the growth of interest in this new science.

In recent competition, well over 100 entries have been submitted each year from all over the nation and several foreign countries. In 1957, the first year of the competition, there was a total of only 53 entries. The list of entries in the competition reads like a *Who's Who* of missile, aircraft, and electronics industries, research and medical centers, as well as a register of hitherto unheard-of organizations and individuals.

The most significant fact about entries has been the

strikingly discernible trend away from miniaturization of mechanical parts toward miniaturization of electronic parts. In 1958 the number of entries pertaining in one way or another to tools and parts, valves, mechanical motors, switches and instruments, was just about equal to the number of entries concerned with miniaturization of computers, transducers, amplifiers, and other electronic parts for both industrial and defense purposes. In 1959, however, the number of entries for electronic parts was vastly greater than the number of entries for mechanical miniaturized items; most entries related to microcircuitry, integrated circuitry, solid-state circuitry, molecular electronics, and molectronics. The more recent entries indicate the large number of significant advances in the field of medicine and micro-surgery.

Recent far-reaching developments have paved the way for this trend. Development by General Electric of the tunnel diode has opened up new possibilities for miniaturization of many electronic components hitherto available only in standard sizes. The tunnel diode is a first cousin to the transistor but operates on a different principle, and is smaller, simpler in structure, little affected by environmental conditions, and resistant to the damaging effects of nuclear radiation. Further utilization of this important development can be expected.

Impressive advances in electronic computers are now being made as a result of the recent development of another miniaturized product. At MIT, in association with Francis Associates, of Marion, Mass., a complete digital computer has been perfected which contains logic and memory sections, and associated clock and input-output circuitry, but which occupies only .12 cubic foot compared to .4 cubic foot of an identical computer using a printed-circuit package. Development of an original molecular electronic concept by Westinghouse, in cooperation with the Air Force, has enabled manufacturers to produce many other miniaturized electronic components, such as a solid-state amplifier, a multi-vibrator, and a timed amplifier.

Incentive for these advances is quite clearly the government's stepped-up program for development of missiles and satellites. In 1958, for instance, only three companies from California, home of most of the big aircraft and missile industries in the country, submitted entries to the Awards Committee. By 1960, however, California led all other states with 30 entries. New Jersey and Pennsylvania, both with a high concentration of electronics industries, reflected this trend with larger numbers of entries in recent competitions. New York, with a heavy concentration of

aircraft industries on Long Island, also has showed a steady interest in the competition. New England, with its skilled craftsmen in many industries, shows steady interest annually but less emphasis on electronics.

Another noticeable trend in the Awards competition was a greater number of completed assemblies, rather than mere parts, submitted by the larger companies. The reason was believed to be an attempt by the companies to meet strong competition in the field of miniaturization by providing customers with as much convenience as possible.

Finally, the trend in entries indicates that miniaturization manufactures are slowly beginning to make a bid for the vast consumer market which previously had been largely ignored. In the 1958 competition three consumer items were submitted: a new and smaller camera flash bulb, a portable TV, and a tape recorder. In subsequent competitions an electronic wristwatch, a micromotor one sixty-fourth of a cubic inch in size, new computer designs, a battery the size of an aspirin tablet, a tiny 150-watt light bulb, a miniature phonograph, a hearing aid the size of a thumbnail, a two-way wrist radio, and a new miniature transistor radio were submitted.

WHAT OF THE FUTURE?

As far as future competition is concerned, what will turn up? Will there be a Buck Rogers ray gun among the winners? Or will we have to wait until 1965? Sooner or later all things will be possible through miniaturization. The science is just beginning.

In the not-so-distant future there should be a substantial market for automatic miniaturized detection equipment. This equipment may prove to be of immense help in locating missing aircraft and space vehicles. It should also be of value to the earth bound. Where burglary is a possibility an automatic transmitter concealed inside a package wil go into silent operation as soon as the package is moved, acting as a beacon to lead police to the place where the stolen goods are concealed.

In the field of medicine, scientists at General Electric are already working on replacing faulty organs in the human body with tiny electronic equivalents. It may soon be possible, by means of miniature TV cameras, for one nurse on a hospital floor to monitor the condition of dozens of patients from a central location, checking each patient visually.

These possibilities are tame, however, in the light of predictions made by some responsible physicists. Dr. Richard P. Feynman, in a recent talk before the American Physical Society, pointed out that since it is now possible to write the Lord's Prayer on the head of a pin, it should soon not be impossible to write the entire Encyclopedia Britannica on the head of a pin. How long, he goes on to ask, before we can put the world's entire collection of books on the head of a pin? According to the laws of physics such a possibility could become a reality. Dr. Feynman further suggests feeding mechanical "surgeons" into the heart which would explore first and then use a small knife to perform the necessary operation. To make such a device he predicts the invention of lathes and other machine tools no larger than a quarter.

Whether or not Dr. Feynman is correct about specific developments is beside the point, as he himself is quick to admit. What is important, however, is that the field of miniaturization knows no bounds. Only his limited technology prevents man from making smaller and better devices. The greatest example of miniaturized efficiency at the present time is man himself. One computer expert has described the human body as a 10-cycle computer in a 0.1-ton chassis with a 0.1-horsepower motor. The number of elements inside the bone box of the skull are infinitely greater than the number of elements in the most advanced computers. It is only because of their microscopic size that they are able to function so efficiently in such a small space. Is it not conceivable that man might someday create a computer as complex yet as small as the human brain? Perhaps not, but the goal is there to aim at, and there should be many fascinating and wonderful adventures along the way for those ambitious enough to accept the challenge.

Topics covered: *decision making*
problem solving
creativity
management training

Reading time: *25 minutes*

JUDGMENT

By Sir Geoffrey Vickers

I am honoured to have been asked to give the sixth in this series of lectures, founded to perpetuate the memory of Edward Tregaskiss Elbourne, to whom, as founder of the Institute of Industrial Administration, the British Institute of Management owes a special, as well as a general, debt of gratitude. My five predecessors have painted comprehensive pictures, worthy of the wide-ranging interests and unifying concepts of the man we are here to honour. My approach is more selective. I ask you to consider one only of the qualities which are needed for management: the quality of good judgment. But my short title will invite us to a longer journey than we shall compass in the period of the lecture.

I choose this subject because it fascinates me, but I have more respectable reasons for my choice. Judgment is an important quality in a manager; perhaps more eagerly sought and more highly paid than any. It is also an elusive quality, easier to recognize than to define, easier to define than to

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teach. To some it has an aura of mystery, suggesting unidentified, intuitive powers behind the inexplicably accurate hunch. Others believe that its deepest secrets are already familiar to those who programme computers. Our language and our thought on the subject are alike imprecise. If I can contribute to their better ordering, I feel that I shall be doing something worthy, at least in intention, of an Elbourne lecturer.

We use the word judgment in many contexts. Applying it to business executives, we have in mind, I think, the power of reaching "right" decisions (whatever that may mean) when the apparent criteria are so complex, inadequate, doubtful or conflicting as to defeat the ordinary man. Even in this sense judgment is, of course, not confined to business executives for it is required equally by statesmen, generals and princes of the Church; and even in this sense we may be unsure where it begins and ends. When our Government in 1940 shipped tanks to Egypt, through precarious seas, away from a country still in danger, to take part in operations still unplanned, Sir Winston Churchill took responsibility for a decision, apparently rash, which was justified by results. Shall we call this "good judgment?" What of the decision of Bolivar, when, in the swampy delta of the Orinoco, he announced to a few ragged followers that he had that day founded the Republic of Gran Columbia and had fixed its capital at Bogota, a thousand miles away across the Andes? He too was justified by results. Are these exercises of the same faculty which led Mr. Henry Ford to create Model T40?

Judges of the Supreme Court exercise judgment; yet politicians and civil servants, who take what they call administrative decisions, have generally maintained, in a controversy now thirty years old, that the rightness of their judgments is not a matter which courts of law can competently review. The opposite view is now gaining ground. What is the difference between the judgment of judges and the judgment of administrators?

What of the scientists? Vesalius rejected the view, accepted in his day, that the dividing wall of the heart is pierced by invisible passages. He proved to be right, and he is rightly remembered as a hero of scientific scepticism. Harvey assumed the existence of invisible passages connecting the arteries with the veins, an assumption then new and commended only by the fact that it was required by his theory of the circulation of the blood. He proved to be right too; and he is rightly remembered as a hero of — scientific intuition. Did these two men show "good judgment" in the same sense?

What of the doctor making a diagnosis? What of the artist painting out a tone or a form which, in his judgment, disturbs the balance of his picture? What of the connoisseur who chooses that artist's work from among a hundred others, because he judges it to be of higher and more enduring merit? What of the man in a moral dilemma who judges one personal claim on him to be more weighty than another; and of his neighbours, who judge his decision as right or wrong? All these are exercising judgment; and though their fields are remote from that of the business executive, their activities are not. For the business executive also has occasion to act judicially, to make diagnoses, to weigh moral issues, to judge as connoisseur, even, perhaps, to compose in his own medium as an artist. It seems that we shall have to decide whether the word "judgment" in all these contexts stands for one mental activity or many.

THREE TYPES OF JUDGMENT

I shall distinguish three broad types of judgment. Harvey and Vesalius made judgments about the state of affairs "out there." They revised the currently accepted view of external reality. I will call such judgments "reality judgments."

Churchill, Bolivar and Ford also made reality judgments; but they went further. They made judgments of what to do about it; and they committed themselves to action on the basis of these judgments. I will call such judgments "action judgments." In my examples, what strikes us most about their action judgment is that it "came off." In each case it achieved the desired result.

There is, however, a third element in these judgments — the judgment of what result was most to be desired. This I will call a value judgment. Churchill, Bolivar and Ford would not be remembered in these contexts unless they had been convinced of the value of victory in the Middle East, of creating independent republics of the Spanish-American colonies, of building a popular car; and these were not the only judgments of value which underlay their decisions.

In each case the value judgment is separate from the action judgment; it can be separately criticized. That the action succeeded does not prove that it was well conceived. Some strategists criticized the British emphasis on the Middle Eastern theatre of war. San Martin thought that the new states of South America should have been set up as constitution monarchies. Even Henry Ford's "tin Lizzie" was criticized — on aesthetic grounds. Hindsight often leads us to wish that our well-laid plans had failed.

I shall return in a moment to consider the part played by these three kinds of judgment — value

"The higher the level of judgment involved, the less possible it is to find an objective test by which to prove that the judgment is good."

judgment, reality judgment, action judgment — in the making of business decisions. First, I want to inquire how we recognize these judgments as good. The answer is curious and somewhat disturbing.

THE CREDENTIALS OF JUDGMENT

The capillaries which were invisible to Harvey can now be demonstrated by improved microscopy. His judgment has been confirmed by observation. Yet even the so-called facts of observation need judgment to give them meaning, a judgment often difficult and hazardous. Moreover, few reality judgments can be confirmed by observation, even after the event; for many relevant facts of a situation — the state of someone's mind, for example — are not observable and change constantly and unpredictably, not least through the effects of judgments made about them. In the ultimate analysis, all reality judgments are matters of inference and can be confirmed or challenged only by new reality judgments, based on further inferences.

With action judgments we feel on firmer ground; we can check them against their results. Yet this is at best a rough and ready test, especially at the level of my examples. Who can say whether the courses which were not tried would not have worked out better than the one which was chosen? Moreover, every choice involves weighing probabilities. The course rightly chosen as of least risk may none the less prove lethal; the course of most risk may still come off. Results no doubt confirm judgments with some assurance when similar choices are repeated in controlled conditions often enough for the laws of probability to speak with authority; but it is hard to see how such an objective test can be applied to the judgments of the statesman or the top executive. It would seem that the validation of action judgments also is a matter of judgment.

When we consider value judgments we find the same situation in a much more extreme form. The validation of a value judgment is necessarily a value judgment. Churchill, Bolivar and Ford told themselves what they meant by success. Those who disagreed with them could do so only by appealing to different standards, representing value judgments of their own. There would seem to be no means whereby the adjudicating mind can escape responsibility for the standards of value to which it commits itself.

I have distinguished three kinds of judgment, often present together — value judgment, reality judgment and action judgment — and I have reached the conclusion that the higher the level of judgment involved, the less possible it is to find an objective test by which to prove that the judgment is good. The appraisal of judgment is itself an act of judgment. In particular, value judgments are logically incapable of being validated by any objective test. They cannot be proved true or false. They can only be approved as right or condemned as wrong by the exercise of another value judgment.

Does this condemn us to pure subjectivism? In my view definitely not. The status of judgments which are neither objective nor subjective has been analysed on a grand scale, with special regard to scientific judgments, by Professor Michael Polanyi, himself an outstanding physical scientist — and I find myself broadly in agreement with his views, as far as I understand them — but to pursue the philosophic issue involved would take me far beyond the limits of this lecture. Nor need I do so, for the concept of responsible choice — that is, of decision which is personal yet made with a sense of obligation to discover the "rules of rightness" applicable to the particular situation — is a familiar concept in business, which we trust and use many times a day, even though neither philosophers nor psychologists can explain it.

JUDGMENT AND DECISION

We sometimes use the word "judgment" as if it meant the same as "decision," but this is too narrow an interpretation. A good judge of men, for example, *reveals* his good judgment by the appointments and changes he makes, but the judgment which guides those decisions is something which he exercises continually as he observes and appraises the people around him. I will ask you to consider an example of this sort in some detail.

One morning, Mr. Redletter, the managing director of The Weathercock Company, (all the characters in my illustrations are imaginary) reached the conclusion that the company's chief supplies officer, Mr. A, was not up to his job; that somehow he must be re-

moved from his post and replaced by Mr. B. What precipitated this decision I will inquire later. For the moment I ask you to accept it as a fact and to follow it backwards and forwards in time.

To reach this conclusion Mr. Redletter must have had in his head an idea of where the Weathercock Company was going and of where he wanted it to go; of the part which the supplies department was playing in the company's effectiveness and the part which it should be playing; of Mr. A's performance as its head and of what its head's performance should be; and of the probable performance of Mr. A. All these ideas were the cumulative result of several years' experience of the company and its staff. They were not mere observations, they were judgments. These judgments go in pairs; a judgment of the situation as it is, is compared with a judgment of the situation as it might be. It is the disparity between the two which has moved Mr. Redletter to his decision. These are the two types of judgment which I have already distinguished as reality judgment and value judgment. They are closely connected.

Mr. Redletter's idea of Mr. A is not a mere catalogue of Mr. A's past performance. It is an hypothesis sufficiently comprehensive to explain all he knows about Mr. A, and from which he can assess Mr. A's probable performance in various roles; his potentialities and power of learning; his current trend of development or deterioration; his probable response to promotion or transfer. Even so, it is not complete. It is selective and the selection reflects the nature of his interest in Mr. A, which is that of a manager in a functional subordinate. Mr. A's doctor or wife or colleague on the local borough council would each have a different picture of Mr. A — different not merely because of their differing gifts and opportunities for forming a judgment, but also because of their differing interests in Mr. A. Someone who had no interest at all in Mr. A could have no picture of him.

Thus the nature of Mr. Redletter's interest in Mr. A defines what aspects of Mr. A he shall select for attention and valuation. The same is true of his interest in the supplies department. So when Mr. Redletter asked himself, "Can we wear Mr. A any longer as Chief Supplies Officer?", he found the materials for an answer already in his head. Nor were these merely "raw" materials. They were an accumulation of judgments, leading to ever more complete hypotheses about Mr. A and the supplies department. On the other hand, what he found in his head was not *the* answer. This question redefined his interest and called for a revaluation of the problem, leaving his ideas of Mr. A and the supplies department however slightly changed.

The result we know. For the first time, on this particular morning, Mr. Redletter, comparing his value judgment with his reality judgment, reached the answer "no."

Let us now follow that silent decision forwards. What is to be done? This I have called the action judgment. It takes the form of a dialogue between Mr. Redletter, the man of judgment, and an invaluable but irritating boffin in his head who makes uncritical but sometimes brilliant suggestions.

"Move him to another job?"
"He'd be worse elsewhere."

"Retire him early under the pension scheme?"
"We can't — he's below the minimum age."

"Give him his notice and let him go?"
"We couldn't do that with old A in all the circumstances, it wouldn't be fair."

"Make him an ex gratia *allowance?"*
"Anything big enough to mitigate hardship would be a most awkward precedent."

"Must you really do it now?"
"YES"

Silence: then —

"Well, you could divide the department, leave A in charge of the bit he knows, put B in charge of the rest, let them both report to C for the time being; then, in two years when C retires . . ."

"M'yes. *We might . . ."*

You will notice that all these tentative action judgments except the last one are rejected because they are either impracticable or inconsistent with Mr. Red-

"The gradient of initiative leads from the familiar track, where events are in control, to the uncharted spaces where dreams . . . can and must take charge and where that man is lost who cannot dream at all."

letter's idea of the sort of employer the company wished to be: in other words, by a reality judgment or a value judgment.

I have now squeezed all I want from this example. I summarize the results.

1. Judgment is a fundamental, continuous process, integral with our thinking.
2. It has three aspects —for simplicity, three kinds of judgment — value judgment, reality judgment, action judgment. The first two are the more fundamental and important. Action judgment is only called for by the interaction of value judgment and reality judgment, and is only selected by further use of the same criteria.
3. The aspects of the situation which are appreciated (reality judgment) and evaluated (value judgment) are determined by the interest of the judging mind.

All these forms of judgment are mental skills. It remains to ask in what they consist; and how they may be trained. Before I turn to these questions I will take up one which I have left unanswered. Why did Mr. Redletter reach his conclusion just then? This inquiry will lead me to explore the meaning of initiative and the relation between initiative and judgment.

JUDGMENT AND INITIATIVE

What precipitated Mr. Redletter's action judgment? Had Mr. A just dropped an enormous "clanger," costing the company most of a year's profit? Or had Mr. Redletter so radically revised his ideas of what a supplies department should be that Mr. A's interpretation of his role, though unchanged and accepted for many years, suddenly became intolerable?

These are remote points on a continuous scale. The disparity between reality judgment and value judgment may widen, because of a change either in the situation as we see it (our reality judgment) or in the standards of value which we apply to it (our value judgment). This scale is important and I will illustrate it by two other episodes in the earlier history of the Weathercock Company. The decision involved in both is collective. What I have said applies equally, as I believe, to collective and to individual decisions. In collective decisions, however, varying views on reality, value and action are expressed by different voices and are more easily distinguished than when their clashes and accommodations take place within a single head.

The first episode presents the directors of the Weathercock Company in an emergency meeting one Thursday. The bank has refused to extend the overdraft sufficiently to provide the pay packets on the following day except upon unwelcome and onerous terms. After long debate, the directors accept the bank's terms, telling each other that they have no choice. Strictly speaking they had a choice; they might have said "no" or failed to say "yes," which would have been the same thing. To choose this alternative, however, would be to choose the immediate and irreversible dissolution of the undertaking and of their own authority, and that in the most untidy fashion. The bank's terms raised no objections which could make such a course preferable.

I will now introduce you to the board of the Weathercock Company some years later. The situation has been transformed. Output is maximal, orders and cash are alike embarrassing in their abundance. The only troubles are troubles of growth, and the worst of these is that the company has no longer any physical room to grow.

They are agreed that something must be done but embarrassed by the variety of possible courses and divided on the merits of the few which are seriously considered. Mr. Redletter wants to build a new factory and a new site in a new town 20 miles away; and in it he wants an impressive slice of space to develop a new business in moulded plastics, which, with the reluctant consent of his board, he had set up in some precious floor space of the present works a year or two before.

None of his colleagues supports the managing director; the arguments against his plan are impressive. The firm will lose most of its present employees and face others with hard choices. It will break its connections with its home town and its home site. The economies claimed for the move are offset by an x representing the unknown variables which will be set loose by so radical a change. And why moulded plastics, when the traditional business is doing so well?

The final decision was in no one's mind when the debate began but was unanimously adopted in the end and pleased everyone. The undertaking would stay where it was, make better use of existing space, and would swallow the coveted area begrudged to plastics. It would also buy a large site in the place favoured by Mr. Redletter and build there a small factory — for the moulded plastic business only. Mr. Redletter was well content; his pet venture could expand all the better in this relative isolation; the rest could still move out, maybe, one day later on. The others were content also. They got what they wanted, escaped all threats — and kept the managing director happy. You will note that the managing director, though in a minority of one, got his way in what most mattered

"Where the maker of action judgments must above all be ingenious, persistent and bold, the maker of reality judgments must be honest, clear-sighted and brave."

to him, because all his colleagues felt it was essential to any settlement that they should keep him, and keep them happy. These two situations illustrate what I will call the gradient of initiative.

THE GRADIENT OF INITIATIVE

The first is an extreme case. The company is on the verge of insolvency. An instability — the imbalance between money in and money out — which has been progressively affecting its performance for some time, is about to cross a critical threshold, beyond which its effects will overflow in all directions and bring the system to disorganization and dissolution.

The effect of instability on a system is usually of this form. The most clear-cut example is physical death. A living organism is an organization, maintained by the delicately balanced intake and outflow of air, food and water, and equipped with admirable devices for keeping these balances — and many others — within critical limits. The maintenance of this system is a necessary, though not of course a sufficient, condition for the highest achievement of human intellect and feeling; and among the humble but necessary skills of living we recognize the skill of keeping alive and healthy — normally as a condition of all we want to do with life, occasionally, as when we are escaping from a fire or a furious bull, as an end in itself.

Similarly, for business, solvency is not an end, but it is a pre-condition of successful existence and when threatened it may become an end in itself.

Political organizations such as nation states are similarly liable to changes of this step-function form. There is, however, a difference in the degree of irreversible change illustrated by these examples. The dead organism dissolves; all its constituents rearrange themselves in new and less improbable configurations. The bankrupt business, after liquidation, may reappear more or less changed. Someone will probably carry on much the same business in the same building with some of the old plant. Some of the former employees may be re-engaged. Only the accounts will show a complete break. Alternatively, if technical liquidation is avoided the only continuity may be the old losses, carefully preserved for the benefit of the newcomer's future income tax.

Wars and political revolutions raise even more difficult questions as to the identity of the future system with that of the past. These difficulties are due largely to our habits of language and thought, which invest their objects with an unreal degree of wholeness and independence. I refer to them only to establish two ideas which are important to my argument.

I wish to distinguish first between the conditions which establish a given measure of freedom and the reasons which explain how that freedom is actually used. In my case history, the establishment of the company's liquidity was one of the conditions which enabled it to grow and ultimately to go in for moulding plastics; but it throws no light at all on why the company chose to go in for moulding plastics. For this we must explore the past history of the managing director.

This may seem obvious; but it is often by no means easy to be sure whether a given explanation explains why something happened or merely explains how its happening was possible. The theory of evolution has been supposed for the last century to explain why life on this planet has developed as it has; but serious and respected thinkers today contend that the theory merely explains how that development, among others, became possible.

Arising out of this distinction, I wish to establish the idea that an organization, like an organism, can conveniently be regarded as a hierarchy of systems, each dependent on, but not explained by, those below. The variables which determine the solvency of a business could be described and discussed without any reference to the nature of the undertaking's product, the interests of its staff, the ambitions of its directors or a host of other things which fill the agenda at its meetings. In the first situation, solvency was in such peril that the field of choice was minimal. As with the man escaping from the bull, the preservation of basic conditions had become itself a dominating goal of policy. In the second situation, the basic conditions of existence were sufficiently secure to enable the directors to realize a variety of possible values, even some which they had not contemplated before. The future depended not on the adroitness of their actions but on the quality of their dreams. The gradient of initiative leads from the familiar track, where events are in control, to the uncharted spaces

where dreams, whether "right" dreams or "wrong" dreams, can and must take charge and where that man is lost who cannot dream at all.

Thus skill in value judgment is increasingly demanded as human initiative widens. It is to be expected that some leaders who show the greatest resource in conditions of extreme difficulty will be less successful when they must seek guidance, not from without, but from within themselves.

THE ACTION JUDGMENT

I will now revert to the question left unanswered at the end of an earlier section. What are the mental processes underlying the three aspects of judgment?

The judgment which has been most carefully studied is what I have called the "pure" action judgment. This is typified in Kohler's classic learning experiments with apes. The motivation (value judgment) is standardized; the animal wants a bunch of bananas which is out of reach. The situation is standardized; the materials for a solution are all in sight. Only one solution is possible, so no choice between solutions is involved. The means to be used — a hooked stick, a few boxes — are not, as far as can be avoided, charged with an effective meaning of their own. The issue is simply whether the creature can see how to use these neutral objects as means to an end.

The process by which one ape does, while another ape does not, succeed — suddenly, but after prolonged incubation — in "seeing" the boxes as a potential increase in height, the stick as a potential increase in reach, remains a fascinating psychological puzzle.

Now consider a human example. As a very inexperienced subaltern in the old war, my company commander once said to me, "Vickers, the company will bathe this afternoon. Arrange." In the Flemish hamlet where we were billeted the only bath of any kind was in the local nunnery. The nuns were charity itself but I could not ask them to bathe a hundred men. I reviewed other fluid-containing objects — cattle-drinking troughs, empty beer barrels — and found practical or ethical objections to them all; and at that point I had the misfortune to meet my company commander again and was forced to admit that I had not yet found the answer. He was annoyed. "Whatever have you been doing all this time?" he said, and then, turning his own mind to the problem, as it seemed for the first time, he added, "Take the company limbers off their wheels, put the tilts inside, four baths each four feet square, four men to a bath, do the job in an hour, why don't you use your brains?"

Simple indeed; but his solution involved two steps which my mind had not taken — the apprehension that a vehicle is a collection of bits and pieces, of which, for some purposes, the wheels may be irrelevant; and the apprehension that a tilt tailored to cover a protruding load and keep rainwater out, would fit and serve equally well, pushed into the empty wagon, to keep bathwater in.

My company commander—unlike myself—showed a mental ability like that of Köhler's more successful apes, though higher in degree; a facility for uncoupling the elements of a familiar idea and recombining them in a new way — for seeing a limber as two potential baths on irrelevant wheels, without forgetting that it is primarily and must again become a vehicle. This is a faculty useful in the research and development department and equally in the board room. Let us call it inguenity.

THE MEANING OF INGENUITY

Yet it must involve more than we usually associate with ingenuity. The mere multiplication of alternative means to an end might only make the choice harder, unless it were accompanied by some gift which guides the problem-solver in the general direction of the still undiscovered solution. The literature of problem solving, no less than common experience, attests our capacity for searching with a lively sense of "warm . . . warmer . . . *warmer* . . ." when we do not know what we are looking for.

It would seem then that even the pure action judgment involves mental faculties which are still highly obscure. Yet the pure action judgment is too simple a process to be seen outside the laboratory. Even my efforts to improvise bathing facilities were hedged about with reality judgments and value judgments of great complexity; reality judgments about what our Flemish hosts would stand with equanimity from their British billetees, and value judgments defining the kind of solution which would be acceptable to me,

"This survey . . . may well leave us in doubt how far the mechanical and mathematical models of decision-making — now so popular — . . .are of any relevance."

"No one can exercise good judgment unless he can support both the stress of office in which the judgment is to be exercised, and the stress of the judgment itself."

having regard to its impact on the troops, the inhabitants, my company commander and myself.

The action judgment is involved in answering any question of the form, "What shall I do about it?" when "it" has been defined by judgments of reality and value. In implementing a decision, this question may have to be asked several times. "What shall we do about the supplies department?" "We will change the head." "What shall we do about changing the head?" "We will divide the department and . . ." "What shall we do about this decision to divide . . .?" "First we will tell A and then B and then . . ."

Thus each decision sets a more precise problem for the next exercise of action judgment; and at each stage there is assumed a set of criteria for determining between different solutions. These criteria are supplied by further judgments of reality and value. "That would not be legal." "That would not be fair." "That would not be possible." And so on.

This process has many interesting aspects which I have no time to pursue. I will refer to two only.

First, what solutions are considered and in what order? Professor Simon has pointed out that the solutions which are weighed are usually far fewer than the totality of possible solutions which exist. Often the totality is too large to be reviewed, however briefly, in the time available. Random selection seldom if ever occurs. Some mental process narrows the field rapidly to a short list of alternatives, which alone are carefully compared.

Some elements of this selective process are apparent. A man seeking a solution to a problem will usually review first the solutions which are approved by custom or his own experience for dealing with problems which seem similar; or he may try first the responses which are most accessible to him or which he most enjoys. Occasionally, however, explanations fail us and we have to credit the problem-solver with an intuitive feeling for the approach which is likely to prove fruitful, though we can see no clue by which it is recognized. This is the heuristic element in ingenuity, to which I have already referred.

Professor Simon assumes that the fully rational course is to examine every possible solution and to choose the "best." It seems clear to me that this is not the way the brain works. The criterion, I suggest, is not the best but the "good enough." The human brain scans possible solutions in an order which is itself determined by the complex and obscure factors to which I have referred; and it stops as soon as a solution is not rejected by criteria of reality or value.

If all solutions are rejected and no new ones can be devised, the standard of the acceptable has to be lowered and the process is then repeated. The unsuccessful series of rehearsals is not wasted, for it prepares the mind for the change of standard.

THE REALITY JUDGMENT

I turn now to the reality judgment. This, too, involves analysis and synthesis, often repeated. It requires the ready handling, dissociating, reassociating of the elements in our thought which I have called ideas or concepts. It, too, has scope for ingenuity. Yet it seems to me to require somewhat different qualities of mind.

The problem-solver has his problem to guide him. The reality judgment, on the other hand, leads us as far afield as we let it; for the aspect of the situation with which it is concerned is as wide as our interest, and we can follow it in time until imagination fails us. A gift needed by those who make reality judgments is to know where to stop; to sense the point beyond which the best estimate of trends is not worth making.

The maker of reality judgments is for the time being an observer; not like the maker of action judgments, an agent. He needs detachment, objectivity, balance, a clear head to follow the complex permutations of the possible and the practicable; a stout heart, to give as much reality to the unwelcome as to the welcome. Where the maker of action judgments must above all be ingenious, persistent and bold, the maker of reality judgments must be honest, clear-sighted and brave. Above all, perhaps, he needs a ready sense for those aspects of the situation which are most relevant. And here, too, the man of outstanding judgment shows such an unerring sense for those facts which will be found to matter most that it is safer to give his unexplained facility a special name and call it also an heuristic gift.

THE VALUE JUDGMENT

The value judgment raises problems far more obscure. Clearly it is fundamental; if we were not concerned with values which we wanted to realize and preserve we should have no interest in the situation and no incentive to action. The basic difficulty in all complex decisions is to reconcile the conflicting values involved — in my first example, the supply needs of the undertaking, the deserts of Mr. A, the board's reputation as an employer, the preservation of tacit rules governing promotion and discharge and so on.

All these values are standards of what the undertaking should seek and expect of itself and others. I will call them norms. They are not settled in abstract terms but they are implicit in every major decision. Executives absorb them from these decisions and still more from the experience of participating in the making of decisions, and by the same process they contribute to the setting of these standards and to their constant revision. Thus the maker of value judgments is not an observer but an agent. He needs not so much detachment as commitment, for his judgment commits him to implications far wider than he can know.

In approaching their decisions, executives usually find the appropriate standards of value ready to hand. They cannot depart abruptly either from their own past standard or from those current in their industry. In deciding how to treat Mr. A, for example, the possible range of decision was closely limited. Thus executives, in making value judgments, are seldom conscious of doing more than apply a rule.

Yet, viewed over time, it is obvious that these standards are constantly changed by the very process of applying them, just as the common law is developed and even changed by accumulating precedents. The ghost of the economic man should not persuade us to ignore the fact that business undertakings today are governed by most complex value systems. Those who direct them must somehow provide themselves with standards of what the undertaking expects of itself — standards sufficiently coherent to be usable, yet sufficiently comprehensive to define its divergent responsibilities to employees, shareholders, consumers, suppliers, locality, industry, government and community. In every one of these fields the standards of industry today are markedly different from what they were a few decades ago; and the standards of individual undertakings differ from one to another and also change with time.

Thus in every value judgment there is latent a creative process; a resetting of the norms which are being applied.

We can as yet give no satisfactory account of the process by which we resolve problems of conflicting value. We only beg the question when we talk of maximizing satisfactions, for the satisfactions we maximize are set by ourselves; and there is no evidence that we reduce those disparate imponderables to a common measure, so that they can be added and weighed. There is indeed much evidence that we do not.

I have already expressed the belief that in the ultimate analysis, the validity of our norm-setting cannot be validated or falsified by results. It can be approved or condemned only by reference to a sense of rightness for which the adjudicating mind must take responsibility. This is obviously true of the artist and the connoisseur of art and conduct. That it is equally true of the scientist is the theme of Professor Polanyi's book. I believe it to be equally true of the business executive.

This survey of the processes involved in judgment may well leave us in doubt how far the mechanical and mathematical models of decision-making — now so popular — as distinct from mechanical and mathematical *aids* to decision-making are of any relevance. On this important and controversial question I have time for only one comment. In so far as these models are concerned only with what I have called pure action judgment they would seem to have no bearing on any of the main issues which I have raised; for the pure action judgment is unknown in real life. In so far as they assert or suggest that the pure action judgment is the typical decision-making situation, they do a vast disservice both to the inquiry and to the undoubtedly great contribution which, with a more modest approach, they could make to it.

INNATE CAPACITIES FOR JUDGMENT

The extent to which we can develop judgment in ourselves and others is limited by our, and their, inherent capacity for the many mental activities involved. In these it seems clear that human beings differ widely. Minds differ greatly in their capacity for handling, arranging and combining the symbols with which we think. They differ in their ability to recognize causal and other relationships within actual or imagined sequences of events. We can say with confidence of some problems that they are too difficult for A to solve: of some situations that they are too complex for B to comprehend.

It may even be that men differ in the faculties they

use. Dr. Grey Walter has suggested that those who are unusually gifted with visual imagination reach some decisions in ways quite different from the ways used by others, not less intelligent, who are unusually devoid of this gift. He claims further that the electroencephalogram distinguishes the two types, each of which contains, he suggests, about a tenth of the population.

Men differ further in the moral qualities involved in judgment. C could comprehend the situation, he could solve the problem: but has he the guts to go on trying until he succeeds? Will the mere stress of having to try impair his capacity for success? (Examinations rightly test this moral quality, no less than the intellectual ones which they are designed to explore.) This difference is so important that we rate executives for decisiveness, as well as for good judgment, reserving the highest rewards for those who excel in both, but recognizing that the ability to decide at all is a prior requisite, and in some cases a major one. Lord Wavell, in some famous lectures on generalship, said that stupidity in generals should never excite surprise. For generals are chosen from that small, preselected class of men who are tough enough to be generals at all. From such heavy-duty animals, refinements of intellect and sensibility should not be expected.

Lord Wavell's dictum, to which he was so notable an exception, is of general application. No one can exercise good judgment unless he can support both the stress of the office in which the judgment is to be exercised, and the stress of the judgment itself. Not all high offices are in themselves as stressful as that of a general in the field; but the stress inherent in judgment itself is inescapable. Between value judgment and reality judgment there is tension, characteristic of all human life. It may lead to the kind of breakdown which psychiatrists meet in patients who have lost touch with reality, or who torment themselves with an impossible level of aspiration. Distortions of judgment due to the same cause are common enough in board rooms, as for instance, when a board is faced with a problem of redundancy too large to be handled within the rules of what it has come to regard as fair. The opposite error of those who protect themselves by failing to aspire enough is more common, and much more wasteful, but more easily overlooked.

Again, the sheer difficulty of keeping the judgment of value and reality from running away into irresolvable complexity is itself a source of stress, and accounts for the familiar distinction between men of action and men of thought. The simplicity which characterizes the thought processes of men of action has often seemed to me excessive; but it is nevertheless essential to individual good judgment that a man's capacity for judgments of value and reality shall be related to his own capacity for action judgment. One of the merits of business organization is that these different human capacities can be combined.

Finally, clear judgment of value and reality only makes more frustrating the common human state of helplessness, when no effective action can be taken; and this is as common in business life as in life at large.

Courage and endurance are not the only moral qualities associated with good judgment. D has guts in plenty but he is conceited, full of personal prejudice, takes offence easily; in brief, is not sufficiently selfless or sufficiently disciplined to achieve that combination of detachment and commitment which good judgment demands.

Finally, apart from these moral qualities, I have expressed the belief that judgment needs that sensitivity to form, which, in various guises, distinguishes the connoisseur of art or conduct, the scientist and the judge, and which is equally required in the business executive.

THE TRAINING OF MANAGEMENT

Have I given the impression that good judgment is to be expected only from those who combine the qualities of philosopher, hero and saint to a degree rarely found even among top people? I hope not. In so far as it involves peculiarly human qualities of intellect, sensibility, character and will, it does indeed give scope for every kind of excellence, yet equally, just because it is so human a quality, it is not likely to be lacking in anyone we recognize as fully human.

It is inded ubiquitous; for it is involved in some degree in every exercise of discretion. Among the debts of gratitude which business people owe to Dr. Elliott Jaques, I give a high place to his finding that, among all the jobs, from highest to lowest, in the undertaking which he has studied so carefully, not one fails to involve some element of discretion, some duty, essential to its performance, which is not and

"... judgment is the most universal requirement not only of managerial work but of all work."

cannot be specified in the instructions given to the holder. We are not paid, says Dr. Elliott Jaques, for doing what we are told to do, but for doing rightly that part of our job which is left to our discretion; and we rate our own and our fellows' jobs on our estimate of the weight of this discretionary element.

If Dr. Jaques is right, judgment is the most universal requirement not only of managerial work but of all work. The distribution of roles on an organization chart may thus be seen, not merely as an allocation of duties but as an allocation of discretions, increasing up the hierarchy in the quality of the judgment they demand.

This picture helps us to answer the question, "How is judgment developed?" The whole structure of industry is or should be a school of judgment, in the course of which individuals may develop, by practice and example, both the general qualities of mind, heart and will which all judgment demands, and their own particular aptitudes which determine the kind of judgment in which they can become most proficient.

In such a school everyone is both learner and teacher. The teaching function is both positive and negative. It is positive in that it requires every member of the organization, in his daily work, to set an example in the exercise of judgment, and to supervise its exercise by those for whom he is responsible. It is negative in that it requires everyone to respect the field of discretion of his subordinates, as he expects his superiors to respect his own — especially when he himself is more expert than they in the same field.

CONCLUSION

As I feared, my short title, like a conjuror's hat, has produced more curious objects than I have had time to examine to your satisfaction or my own. The material is far from tidy; the hat is far from empty; and my time is overspent. Apart from displaying what I believe to be the main dimensions of the problem and setting question marks in appropriate places, I have tried to do no more than to couple the higher executive — in the exercise of this, his most precious and highly-paid endowment — on the one hand with those excellent minds in other fields, whose function he must so often copy unawares; on the other hand, to link him with the humblest servants in his own undertaking, on whose judgment he must rely, as they on his, and from among whom it should be his delight, as it is his duty, to develop minds capable of better judgment than his own.

FAILURES OF MANAGERS

As I observe managers at work, I am struck by the fact that there are large numbers who have all the intellectual capacity to analyze and to reach conclusions. What they lack is the courage, the fortitude, to turn these intellectual conclusions into wise decisions. If I had to pick a single reason for men failing to make the most of themselves, it would be this lack of courage and ability to make wise decisions.

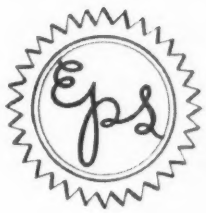
From Dean Stanley F. Teele, "H.B.S. and the Future"
Statement dated October 4, 1960

Topics covered: *revenue laws*
business responsibilities
tax gimmicks

Reading time: *9 minutes*

A TAXPAYER'S DUTY TO HIS FELLOW TAXPAYER

By Merle H. Miller



We are all taxpayers, so that any duty which we owe others, is also owed to us. Since it makes no difference which duty we consider first, I think I shall develop my topic on the basis of the duty owing to us by our fellow taxpayers. Our perspective is apt to be better if we discuss what other taxpayers should do to make our tax life more livable.

We are not speaking of legal duties, for that is the subject of the entire institute. When we look to the dictionary to find out what else is included in the word "duty" besides a legal obligation we find that the first definition is "the conduct due a superior; homage; respect."

On April 16 of any given year the homage and respect due me by my fellow taxpayers is considerable. On that date I will have spent long days listening to anguished laments of taxpayers seeking some way of paying their taxes without selling greatly appreciated securities. I will have finally signed my own return.

At that time I seem to be carrying the full brunt of our defense effort, I must own at least one surface of Echo I. The homage and respect due me on that day by my fellow taxpayers would seem to require at least a doffing of hats and bowing at the waist as I walk along the street. Such recognition has not been forthcoming in the past. Such homage as I receive, comes only from me as I walk along muttering, "Under this hat walks a taxpayer who, without benefit of capital gains, depletion allowance, expense accounts or fringe benefits, is paying the highest rate of anyone in his income bracket excepting some poor bachelor."

Fortunately, the dictionary has other definitions. The dictionary also says that duty is an obligation we owe other people because of our position or occupation. It may be legal or moral. We are concerned tonight with the moral obligations owing by taxpayers one to another, because of their reciprocal positions as taxpayers.

Most of us recognize a duty, whether or not enacted into law, to govern our acts with due regard to the effect which our conduct may have upon others. Our basic question then is, what are the acts of taxpayers that will affect other taxpayers favorably or adversely? Or to get back to our original thesis, what do I wish my fellow taxpayers would do, or refrain from doing in order that my life as a taxpayer might be more enjoyable? In this case wishing will not make it true.

NO TAXPAYER LIVES ALONE

I probably have no right to wish that any taxpayer would accord a Revenue Agent that degree of respect that is due any fellow human being entrusted with a difficult but thankless job. I probably have no right to wish that any taxpayer would resist the temptation to try every legal dodge he has read about over the years and resolve every doubt in his own favor, including doubts as to the reportability of some items. But surely as a fellow taxpayer I am entitled to wish that after encountering such an individual, the Revenue Agent would have examined two or more of the opposite type before he calls upon me.

Unfortunately, in this complicated tax life a man does not always reap what he sows. Sometimes he reaps the seeds of mistrust and animosity sown by an obstreperous taxpayer several times removed.

I should also be entitled to wish that the Revenue Agent would not be riding high because of some absurd concession by the victim immediately preceding. Sometimes absurd concessions are made because the amount is believed to be too small to involve the expense of justifying. More often the absurd concession is made by one who has a gnawing worry about some other item the agent has not questioned and who wants to get rid of the agent at the earliest moment, however ridiculous the issue.

The acts of taxpayers in other areas also have an effect upon us. But we begin to encounter such difficulties that we shall content ourselves with pointing out the effect, without pontificating with respect to any accompanying duty.

OVERWORKED GIMMICK

Even to inquire whether a taxpayer should forego a sure-fire tax gimmick would be to risk playing the leading role in a trial for heresy at our next institute. But if we would guide by the light of reason we must let our minds be bold, so let us look for a moment to the effect on other taxpayers of the over-extension of tax gimmicks.

Deductibility of Officer's Salaries. Time was when a corporation on an accrual basis could accrue salary to one of its officers and obtain a deduction for tax purposes even though the salary was never paid. The officer being on the cash receipts basis would not have to report the salary. The number of taxpayers using this legal method to avoid taxes increased to a point where Section 24 of the old Code, now Section 267 of the new Code, had to be enacted. Thousands of taxpayers have thereby been denied an otherwise legitimate deduction because they did not pay out the amount accrued within 75 days after the end of the tax year. And it is the corporation that is short of cash that gets caught.

Collapsible Corporation. A capital gains tax is apparently a necessary discrimination in our system to enable the necessary turn-over of investments to keep the financial life blood of our economy flowing. But a wholesale conversion of ordinary income into capital gain obviously cannot be permitted. The three pages of understandable collapsible corporation provisions that will ensnare many an innocent taxpayer, are the direct result of perfectly legal attempts by taxpayers to put the capital gains provision to unintended uses.

Thin Corporation. It should be possible to organize a corporation and at the same time lend it some money you are going to need later to pay your taxes, or to pay off the mortgage you placed on your home to get the business off the ground. For years such a natural and useful procedure went unchallenged. Then more ambitious, if less needful, taxpayers wanted to sell everything to the new corporation at inflated values, or issue notes that would cover all anticipated

future earnings. The courts had to invent the "thin corporation" doctrine, and now the government contends that you cannot transfer some property tax-free and sell other property to a corporation at the same time.

Ordinary and Necessary Business Expenses. "Ordinary and necessary business expense" is a phrase easily undertood by all business men. It might require a bit of adjudicating as between expense and capital outlay and possibly with respect to the necessity of some items. But by and large every man knows what he would allow an employee for expenses over and above his compensation — the items he would recognize that should be borne by the company, and what should be treated as personal expenditures of the employee. For years it gave no difficulty.

The fact that we must now have a crusade that will cause inconvenience and even bitterness to all of us is not because of any change in the law. It is not even because the administration of our tax laws has not in the past been indulgent on this point, for we all know it has.

But wherever the line was drawn, there were those who wanted and got more. It was not until the movement to live off expense accounts became a national scandal, that reluctant steps were taken to draft and enforce rules in this area that will admittedly be more unfair, merely by virtue of being fixed rules, than would be a continued fair use of a reasonable standard in each case. As the examining agent wastes our time going over substantiating evidence, we are each victims of taxpayers who tried to ride a good thing too far.

I am not suggesting that we organize a vigilante committee and place offenders in the stocks for all to see. But I do think that the inconvenience they have caused us entitles us to withhold from them some of the acclaim to which they have become accustomed.

TAX DECEPTION AND SOCIAL ACCEPTANCE

Social acceptance is one of the great motivating forces in our lives — second only perhaps to our own economic survival. But after rent and food and necessary clothes, most people strive most for acceptance by their fellow man — recognition of the great guy he really is. Some work for money itself. We call them misers. But most work for the extra money over and above subsistence, because of the belief that it brings greater social acceptance.

In the past, some measure of tax deception has seemed necessary to complete social acceptance. The fellow who was completely at peace with his conscience made his companions uncomfortable. Then he became uncomfortable and decided next year to become one of the boys. Some tried to make up for lost time in a single year and even had to leave "the boys" for a short sojourn.

If we should ever realize that most of our woes are brought upon us not by the original voluntary act of Congress or the dyspepsia of the Revenue Agent, but as the inevitable result of fellow taxpayers who push a good thing too far, our sense of social values will change. It is not our province to judge or condemn. But we need not elevate one exploring the outer limits of a tax gimmick as other than what he is.

He is not seeking after the Holy Grail in behalf of the rest of us. Quite the contrary. He is trying to reduce his own taxes for his own benefit.

TAX PRACTITIONER'S DUAL ROLE

Our dual role as taxpayers and as taxpayers' representatives becomes important at this point. As a taxpayer I have the right to refuse to fudge on my expense accounts because it would stultify me. I also have the right to refuse to use a tax gimmick even though I believe it to be foolproof.

As a taxpayer's representative I have the right to refuse to be a party to any fudging on expense accounts, for in reality it would stultify me even more than the taxpayer. It certainly involves me more professionally than it does him. But if a tax gimmick is above board, does not involve deception, direct or implied, and I have warned the taxpayer of the ultimate fate of most "fool proof" gimmicks, I do not have the right to refuse to aid him on the ground that he owes a duty to the other taxpayers not to get our laws all complicated. I can say that I do not fall for the "cat and rat farm" economic devices which many tax schemes are. But that is exercising a duty to myself and does not arise from my interpretation of his duty to others. At such a time my duty is to my client, to my professional integrity and to no one else.

What, then, is the significance of a discussion of a taxpayer's duty to other taxpayers before a meeting of taxpayers' representatives whose duty runs to the taxpayers they represent and no other? Are we to spend the best years of our lives gaining technical competence, only to be told that use of that competence to the fullest may be only further complicating the lives of others? And that our own individual code of duty prevents our doing anything about it?

But we are not always acting in a representative capacity. In fact our influence on public opinion may be greater when we speak outside that capacity. Because of our training, our comments may be accorded

great weight in social conversations when the topic turns, as it inevitably does, to the complexities and inequities of our present tax laws. Our vision or lack of vision may be multiplied many fold because we are supposed to know whereof we speak. Our influence on public opinion becomes important when we realize that our present system is the embodiment of several basic and deeply rooted conceptions and even privileges. If the present Code is the impossible jungle many believe it to be, no substantial change for the better will be possible until certain misconceptions presently held are changed. And we must lead the way.

L'ETAT C'EST MOI OR, TAXPAYER v. TAXPAYER

The first myth to be dispelled is that in a tax controversy the government is on one side and all the taxpayers on the other. We each know better than that. Actually the government is representing taxpayers who are not in the same situation as the one in court. A court decision for the government is a victory for taxpayers if it means our tax burden will be shared more equitably. A decision for a particular taxpayer is a defeat for taxpayers in general if it means one class is going to get by for less.

Our government is entrusted with the duty of enforcing the tax laws which our representatives have enacted to meet bills for projects they have approved. But the government never picks up any part of the tab. If you create the image of all taxpayers on one side, there remains no one to put on the other side except all the taxpayers. There is no one to pay the bill except taxpayers.

CAN THERE BE A PERFECT CODE?

Secondly, we may have to conclude that we have been expecting too much of our taxing system. We expect our taxing system not only to raise the vast sums we need to maintain ourselves in a garrison state, but we also expect our taxing system to redress wrongs, economic and social, and achieve absolute logical justice in the process.

Our highest aim along these lines is embodied in the 1954 Code. It was well conceived, capably executed and is representative of the majority of well informed views at the time of its enactment. But after six years' experience many wonder whether its basic concept is practical or even equitable. Itself the epitome of refinement, we have been busily fashioning refinement upon refinement since before the ink on the page proofs was dry. The end is not in sight.

Some have come to believe that complexity itself is an inequity and that the complexities inherent in attempting to eradicate minor inequities may result in greater inequity than that sought to be eliminated. As taxpayers we may have to reconcile ourselves to living with a Code that is less than perfect, for the perfect code would be so complex that its inherent complexities would make it imperfect.

NEED FOR EFFECTIVE ENFORCEMENT

Then, as taxpayers we must recognize the all-importance of an efficient, effective taxing system that supplies the life blood to our government. Any action on our part or on the part of fellow taxpayers that endangers that system, puts all of us in peril. No nation outlasts the effectiveness of its system for raising the revenues to finance its operations.

We must support those who enforce our tax laws, for they are really working for us. We keep in the forefront of our mind the lesson of the Eighteenth Amendment. Any law, however well written, can be rendered ineffective by the unwillingness of our people to make it effective.

Evil of Downgrading Service. In this area our duty lies beyond our individual conduct with a given Government employee. We have learned by now that satire and ridicule are the most devastating non-violent weapons placed at the disposal of man, for man lives and strives for recognition and appreciation.

We do not disparage the efforts of those who man the assembly lines where are built the rockets and missiles to provide our security. We do not complain daily about those in the armed forces whom we feel so essential to our coexistence. But by some strange quirk we do disparage, ridicule and even malign those who collect the money with which to pay those working on assembly lines and those in the armed forces.

If our country is to survive, which means that our taxing system must live, we must do more than merely pay our taxes. After paying our taxes in full, we still owe the duty of defending by our daily speech and conduct a strict enforcement system that will command the necessary respect of all taxpayers and share the burdens of taxation equally under the law.

The stakes are high. We are banking our future on a self-assessment system that must of necessity become an honor system. That is why I shudder when those in charge of administering our tax laws take a short-range stand — when an agent proves incapable of using properly the great powers that are literally thrust upon him. I also shudder when tax practitioners seek to curry favor with clients by downgrading those who suggest that additional tax may be due.

Any future failure of our system as an honor system

will not be the fault of our people. The American people are inherently honest.

Our problem is the tuning in of our taxing system with the inherent honesty of the American people, many of whom have never heard taxes and honesty mentioned in the same breadth. The question that remains is: "What can I do as a citizen to make this inherent honesty a dynamic force in our taxing system?" I suggest:

(1) I can compute my own individual tax liability on the honor system and admit that I do so.

(2) I can pay the full liability as shown, with even some concessions in the knowledge that a great deal more would not be an overpayment for the privilege of American citizenship.

(3) I can speak out daily, even in front of clients, of the necessity of a strict enforcement of our revenue laws if our country is to meet its commitments at home and abroad.

This I do in the knowledge that only thus can we move forward to whatever role destiny has for our great nation, with the burdens of that effort shared equally and equitably under the law.

RULE OF "REASON" IN EXPENSE ACCOUNTS

In general, executives are expected to be guided by "good sense," "good judgment," "honesty," and "responsibility" when spending company money. They are supposed to be aware of their duties and obligations to the company, and know that they will be judged by the reasonableness of their expenses. With this in mind, we asked:

¶ "Does your company make known some sort of yardstick for reasonable executive expenses?" The answers:

Yes 39.3% *No* 60.7%

An examination of these replies for differential treatment of executives at various levels in management shows that executives in the lowest level of management are much more subject (48.1%) to such explicit "yardsticks" than are those at the top (34.6%).

Why do companies consider "reasonableness" as the best dimension for deciding what to spend? Why do they not define some explicit dimensions? To discover the reason, we asked executives whether they agreed or disagreed with this statement:

¶ "The trouble with establishing a yardstick for expenses is that if it becomes known, the maximum becomes the standard." Their reaction:

Agree 83.4% *Disagree* 16.6%

Thus, whatever the amount spent by an executive, it will be judged by management according to a rule of "reason." At the same time, the degree to which an executive meets or fails to meet this test in his expenditures represents, to management, an important signal of his over-all competence.

From Edward E. Furash, "Problems in Review: Expense Accounts"
Harvard Business Review, March-April 1960, p. 16.

Topics covered: potentials of computers
programming

Reading time: 14 minutes

COMPUTER CONVERSATION COMPARED WITH HUMAN CONVERSATION

By Patrick J. McGovern

Can a computer think? The answer usually given to this question is expressed in the personal outlook of the person answering to the extent that the word "thinking" has a personal meaning for him.

If he is an intuitionist, and believes that "thinking" means all the emotional vibrations, intellectual nuances, and speculative gestures that he believes he is sometimes conscious of, then he would probably be very reluctant to admit that a piece of machinery, no matter how complex, could duplicate the physiological and psychological events that constructed his mental experiences.

If, on the other hand, he is a behaviorist, and defines "thinking" as those processes that lead an organism, particularly a human being, to perform those actions accepted by others as intelligent behavior, i.e., having some goal in sight that is beneficial to the organism, and having in at least a crude way a systematic pattern of performance, such a person might

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be willing to admit that a computer was "thinking" if it was able to simulate one of these commonly accepted forms of intelligent behavior.

This latter viewpoint led the famous English mathematician A. M. Turing twenty years ago to suggest that a computer could be said to be capable of thinking if it could carry on a conversation with a human being in another room in such a way that the human being could not tell whether he was conversing with a computer or with another person. Since that time this definition of computer "thinking" has stood as a challenge to computer workers that has not yet been satisfactorily answered.

This paper reports an approach to the satisfactory application of this criterion, presents a program that illustrates this approach, and analyzes the success of this program by a technique analogous to that suggested by Turing.

CHARACTERISTICS OF A CONVERSATION

In examining the problem of conveying meaning in a conversation, we see that there are rules and regulations commonly known as grammar which do not permit a structureless jumble of words to comprise a conversation. Similarly, there is a structure to individual word groups, sequences of word groups, and operations between word groups that enable them to express meaning in a conversation.

Meaning in a conversation is a sequence of thoughts expressed by word groups, or symbol groups comprising a punctuation mark, a word, or a group of words. A thought, as defined here, is identified by:

(1) A key word or pattern of words which expresses the subject at hand.
(2) A modifying word or words which pinpoint what we wish to say about another thought group.
(3) A word or pattern of words which operates on the subject at hand.
(4) A key word or group of words which identifies an object, or the thing operated upon.
(5) A key word or group of words which identifies the modification to the object.
(6) A key word or group of words which identifies spatially and temporally, the modification of the operator thought.

With these thought groups defined, we can approach a working definition of a conversation as: an exchange of thought group sequences between two or more persons during which thought sequences are generated by the meaning of the remark that the person has listened to, the environment in which the remark is made, the knowledge and experience of the person, and the emotional state of the person at the time. The interaction of those four factors is the control mechanism in the generation of conversational statements and replies.

CONVERSATION TYPE TO BE USED BY THE COMPUTER

Clearly an attempt to program a computer such as the IBM 704 to carry on an intelligent and responsive conversation with a human being in a wide range of subjects is too complex a task to accomplish immediately. However an effective beginning to the problem can be made by choosing a common everyday topic of conversation and preparing this for machine operation. A reasonable choice is the topic of the weather, for it is an aspect of life about which almost all people have personal knowledge, and have the capacity to conduct conversational thought exchanges. The topic of the weather was chosen for this computer-person conversation program.

OUTLINE OF A COMPLETE PROGRAMMED CONVERSATION

For a complete programmed conversation the computer must have the following abilities:

(1) Ability to take in the input remark as words.
(2) Ability to convert the input words into a "machine language" which the machine can handle by its logical and arithmetical instructions.
(3) Ability to manipulate the word groups in such a way as to construct an image or representation of their meaning.
(4) Ability to search for, and choose one or more thought groups that are reasonably associated with the input remark.
(5) Ability to arrange the selected thought groups in the appropriate order so that they have a meaning that is pertinent to the input remark and to express them in words, thus forming a reply.
(6) Ability to print out this reply.

The only recorded effort to construct a program for conversation with a computer was presented in an article by L. E. S. Green, E. C. Berkeley, and C. C. Gotlieb in *Computers and Automation* for September, 1959, and in a paper at the December 1959 conference of the A. A. A. S. (See references 1, 8.) This attack on the problem ignored the grammatical implications of the input words, and their relations to thought groups. This approach treated each word as a separate unit, and assigned to each word two numerical constants (q,d) which specified the quality and the degree of each input word according to an arbitrary classification system constructed by the programmer. From the character of the input words they arranged for the machine to select a certain output frame out of a

collection; each frame contained blank spaces for the insertion of specific output words. Upon selection of the appropriate reply frame by a successive comparison technique the computer would then consult its output vocabulary dictionary for the output words that would come closest to fitting both the class of input remark and the style of the output frame.

The authors stated that "the present program contains very limited recognition of many parts of English syntax." This they consider to be the major factor in the "crudity" of their results. They leave the problem with the statement that "an unsettled problem is how little additional syntax would have to be included so that the program would plausibly imitate a man."

ASPECT OF THE CONVERSATION PROBLEM COVERED IN THE PRESENT PROGRAM

This last remark is the essence of the attack on the problem presented in this investigation. The features of the present program are:

(1) Each input remark is broken down into thought groups similar to those defined above.

(2) Two numerical constants are assigned to each thought group, one specifying the grammatical character of the thought group, and the other specifying the quality or type of thought group with reference to a certain classification system.

(3) Prepared output reply frames are provided to the computer; one is selected depending on the characteristics of the operator thought group of the input remark.

(4) Each reply frame has self-contained instructions that modify the essential thought groups of the output frame in accordance with the thought groups of the input remark.

All the above routines are included in the present program with the following exception: The thought groups of each input remark were coded, according to the arbitrary classification system used in this problem, by the human programmer himself before submission to the machine. In other words, the machine was presented with two numerical constants associated with each of the input thought groups, instead of having to search in a self-contained dictionary for the proper equivalent in the numerical bi-coded system. This procedure was followed because the preparation and use of a complete dictionary subroutine takes an enormous amount of time for the programmer, and consumes large amounts of machine time. Furthermore, the establishing of a one-to-one correspondence between input thought groups and machine-stored thought groups and associated numerical constants is not logically difficult. The present program is largely experimental in its handling of the logical relationships between thought groups in order to construct convincing conversation; the dictionary therefore can be prepared later when a full demonstration of the conversational powers of the computer are required, and when the logic of the computer program has proven itself equal to the task. Also, finally, the problems associated with the construction of a large machine-stored dictionary are amply dealt with in the literature of the machine translation field. (See references 2, 3, 4, 5, 6, 7.)

SAMPLE COMPUTER RESPONSE TO AN INPUT COMMENT

A sample computer response to one of the input statements is here presented to illustrate the operation of the program in the computer.

The input statement No. 17 is "June is the warmest month as all brides know." The computer receives the following octal information in its registers:

Subject registers: 604164452560
which is JUNE in BCD form.
Subject modifier register: 000000000000
Verb register: 300000000010
which indicates a verb of the "identity"
type (which "is" truly is).
Adverb register: 000000000002
This is stored in adverb register if there
is no negative word in the sentence.
Object registers: 606621514425
626360444645
633060606060
which is THE WARMEST MONTH, stored
in BCD form.
Object modifier register: 000000000000

This storing is accomplished by having the computer convert the alphabetic characters to binary coded decimal form, and by further steps.

After storing the above octal words in their appropriate registers, the machine searches the input words for the type of sentence the input comment is. The period in the sentence indicates to the machine that it is a "statement" comment; it then transfers to the statement subroutine. The period is coded as 000000-000003 (see Table 1).

The machine then extracts the value of the bits in Columns 30 to 32 of the verb register, which in this case is a one. The machine then transfers to the instructions for printing the reply frame No. 1.

This reply frame is of the form: "Well, (insert subject of the input comment) is certainly (insert object of the input comment) indeed. But that is the way I like it." When the inserts have been selected from the subject and the object registers respectively, the

complete reply will read: "Well, June is certainly the warmest month indeed. But that is the way I like it."

All runs were made on the IBM 704 with the MIT Automatic Operator Program assembler and operator.

CHECKING THE ADEQUACY OF THE COMPUTER PROGRAM

Before proceeding to complete and run the program we considered how to evaluate the success of a program of this type. This is a challenging problem.

A direct method of testing was sought. The following was finally decided upon:

(1) A group of 25 input statements selected more or less at random from a large set of weather conversations actually collected from human beings would be given to the machine. The input statements would include statements of preference, exclamations, questions, or commentary.

(2) The same group of input statements would be given to a more or less randomly selected group of 9 human beings, and they would be asked to give their verbal reaction to each of the input statements.

(3) The single reaction of the machine, and the 9 reactions of the people, to each input statement, would be listed, but the order scrambled.

(4) A different group of people would then be shown the 25 input statements and the 250 replies (10 next to each input statement) and told the situation — that one of the 10 replies in each set had come from a computer, and that the others were from human beings. Each person in this group would then be asked to judge which one of the 10 replies for each of the 25 statements was from the computer.

(5) The degree of success of the latter group of judges in selecting the computer's replies would be taken as a measure of the failure of the program to fulfill the conditions of the problem. Thus, if the latter group were unable to point out the computer replies with any better than a random correlation, then the present program could be considered a success; and a solution to the conversation-with-a-computer problem in one field, namely, weather conversation, would have been obtained.

II.

COMPUTATIONAL PROCESS

The steps in the computational procedure were as follows:

(1) Write name and title of program.
(2) Print the input remark.
(3) Analyze input thought groups, and place them in one of seven registers depending on their grammatical character.
(4) Analyze the over-all meaning of the whole set of thought groups to see if it is a question, a statement, or an exclamation.
(5) Direct the computation process into the appropriate subroutine depending on the result of step (4).
(6) Check the input statement for a thought group specifying a negative relationship.
(7) Direct the computational process into the negative mood if answer to step (6) is yes.
(8) Analyze the character of the operator thought group for quality.
(9) Direct the computation of output frame in accordance with result of step (8).
(10) Select reply frame.
(11) Execute the self-contained instructions of the chosen reply frame.
(12) Assemble the output frame.
(13) Print the selected and assembled output frame.
(14) Check for end-of-sequence of input statements.
(15) Go back to step (3) if more input statements are available.
(16) If no more input statements are available, print end of run, and halt and transfer.

LAYOUT OF DATA IN THE PUNCHED CARD

The layout for storage of information in the punch card input about thought groups is summarized in the following:

Columns	*Information Stored*
1-3	Constant indicating grammatical class of input thought group, i.e., in binary storage 110: object modifier th. gp. 101: object th. gp. 100: operator modifier th. gp. 011: operator th. gp. 010: subject th. gp. 001: subject th. gp. 000: undefined
4-26	Not used; blank.
27-32	Quality of thought group as numeral constant, i.e., for operator thought groups, 000110: desired, or wanted 000100: happening 000011: conception 000010: like or preference 000001: identity, tautology for operator modifier thought groups 000000: negative aspect 000001: positive aspect
33-35	Constant denoting the class of meaning for the sequence of thought groups, i.e., 001: question 011: statement 111: exclamation

SUMMARY OF PRESENT PROGRAM STATISTICS

In the present program the degree of elaboration is as follows:

(1) The number of input statements used was 25.
(2) The number of output frames available to the computer was 30.
(3) The number of self-contained instructions in the output frames: 51.
(4) The number of grammatical classes used: 10, including the type-of-statement indicator.
(5) The number of classes of operator thought groups: 10, including the ones defined by the negative modifier.
(6) The number of instructions in the program: 845.
(7) The number of decisions for each input statement: 9.

Each of the above is a first approximation. Each could be substantially increased, with improvement to be expected in the performance of the program as a whole.

In the evaluation of the program results, the input statements were shown to nine people, and their responses to each

"It will not be many years . . . before the operating of computers with ideas will be widespread."

statement collected. Their responses were punched on IBM cards arranged randomly with the computer responses, and the whole 250 statements listed by the IBM 407 tabulator. Then the entire listing was given as a questionnaire to 10 other people, who were each asked to point out the computer reply. The questionnaire appears in this issue of *Computers and Automation* entitled "Can You Tell the Computer's Responses from the People's Responses?" The results of this procedure are shown in Table 1.

TABLE 1

Input Statement No.	*No. of Correct Choices*	*No. of Incorrect Choices*
01	1	9
02	1	8
03	2	8
04	2	9
05	1	9
06	1	9
07	1	9
08	0	10
09	1	9
10	1	0
11	5	5
12	1	9
13	5	5
14	1	9
15	0	10
16	4	6
17	3	7
18	3	7
19	1	9
20	2	8
21	2	8
22	1	9
23	2	8
24	0	10
25	0	10
TOTALS	42	208

The results in Table 1 mean that the judging ability of the people for the 25 cases of output of the conversation program was 42/250 or 0.168 or 16.8%. This compares with the 10% that would be expected with completely random guessing and the 100% that would be expected if their guessing was perfect. If we should exclude input statements No. 11 and 13, which were guessed by half the judges, and therefore were rather obvious machine production, the experiment demonstrates that the computer can in the great majority of instances generate conversational responses that are practically indistinguishable from those generated by intelligent human beings.

III.

DISCUSSION

Analysis of the results show some interesting defects in the present type of programming, and suggest several improvements that can be made to polish the present approach. For example, in statement No. 12, the input is "I enjoy nothing more that rainy days in April." The phrase "nothing" is taken by the machine to be a negative, and the output reply comes in the negative mode. ("Neither did I," etc.) However, here "nothing" is coupled in the phrase "nothing more" which uses this negative word to re-enforce a positive assertion. This confusion might be overcome in a modified program by inserting an additional subroutine which compares the negative thought group with its immediate surroundings to see if it fits into any of the frequently occurring combinations of "positive assertion by denial" phrases. Then these could be re-established in the positive mode. However, such a task is not a small assignment, and it would have to be accompanied by considerable analysis of patterns of expressions and commonly occurring syntax, in order for it to function effectively.

Another limitation of the present program is that it incorporates no memory of previous statements; the present program cannot modify the output statement to avoid contradiction of previous replies. In order for the computer to carry on a continuous conversation with someone and to meet the full details of Turing's criterion, some form of memory would have to be available to the machine so that it could not only modify its output statements on the basis of former output statements, but that it could also detect contradictions in the input remarks of the co-conversationalist. This additional ability would involve a great expansion of the present program, and many man-hours. However there is no reason to believe that no attempts will be made to accomplish this in the future.

The present program could be most readily improved by expansion in the number of categories that each grammatical thought group can be placed in. Also the number of output reply frames, presently quite limited, could be easily expanded to provide considerable variety to the output forms, and to make each frame more appropriate to the corresponding type of input statements.

CONCLUSION

It has been shown that by using a relatively simple application of logical syntactical analysis of English sentences concerning the subject of the weather, it is possible to provide an electronic computer with the capability of creating responses in the form of English sentences which are largely indistinguishable from those expected of human beings.

The approach to the conversation-with-a-computer problem which has been presented in this paper is

"When computers do operate . . . with ideas, it will be impossible for a human being in another room to tell whether he is conversing with a computer or with a human being."

found to be successful by a statistical evaluation test, and to indicate that a grammatical attack is fruitful in solving the problem of programming a computer to handle thoughts with words.

References

(1) E. C. Berkeley, L. E. S. Green, and C. C. Gotlieb, *Conversation with a Computer,* Paper presented at the meeting of the American Association for Advancement of Science, on December 28, 1959.

(2) Ashby, William Ross, *Design for a Brain,* New York, J. Wiley, 1952.

(3) Feldman, C. G., *A Digital Computer Analysis Method For Simple English Sentences,* MIT Mathematics Department Thesis, MS Thesis, 1959.

(4) Booth, A. D., Brandwood, L., and Cleave, J. P., *Mechanical Resolution of Linguistic Problems,* New York Academic Press, 1958.

(5) Harvard University Computation Laboratory, *Mathematical Linguistics and Automatic Translation,* Report #NSF — 3 to NSF, 3 August 1959.

(6) Heller, G.G., *Programming the IBM 704 for Language Translation,* MIT Humanities Department Thesis, BS Thesis, 1959.

(7) Locke, W., and Nash, W., *Machine Translation of Languages in A Machine Translation,* edited by Locke W., and Booth, D.D., John Wiley and Sons, New York, 1955.

(8) L. E. S. Green, E. C. Berkeley, and C. C. Gotlieb, *Conversation with a Computer,* in *Computers and Automation,* Vol. 8, No. 10, Oct. 1959, pp 9-11.

APPENDIX

Reference 1 has not heretofore been printed. It consists of a short Section 1, a long Section 2 which consists of most of Reference 8, and a short Section 3. Parts of the paper are given below:

CONVERSATION WITH A COMPUTER

(Paper Presented at the Meeting of the American Association for Advancement of Science, on December 28, 1959, by E. C. Berkeley, L. E. S. Green, and C. C. Gotlieb)

1. Introduction by E. C. Berkeley

First, let me say that I am reporting on work by three people, and two of them have not had an opportunity to review what I am saying here. So please consider that my colleagues, Dr. C. C. Gotlieb, of the Computation Centre of the University of Toronto, and Mr. L. E. S. Green, of K. C. S. Data Control, Toronto, are not necessarily fully committed to what I shall say here.

Can a computer carry on a conversation? The answer to this question is "Yes," and the proof is here exhibited.

We are interested in this question, among other reasons, because the English mathematician Turing, about 20 years ago, suggested that a machine could be said to be capable of thinking if it could carry on a conversation with a human being in another room, in such a way that the human being could not tell if he were conversing with a machine or with another human being. Since that time, this definition of a computer's thinking has stood as a challenge to computer people.

To make a beginning on the problem, it is clearly desirable to restrict it to some relatively simple and common subject such as the weather. About 1954 John W. Carr, III, now director of the computing center at the University of North Carolina, in a course on computers for students at the University of Michigan, assigned as an optional problem for additional credit the problem of programming a machine to carry on a conversation about the weather. But no student took up the challenge.

In December, 1958, the problem (which I phrased and analyzed as a part of a study I was making on language, ideas, and computers) was discussed with the Computation Centre of the University of Toronto. Dr. C. C. Gotlieb of the Centre classified it as a frontier problem having interest; and it was placed in the hands of L. E. S. Green, mathematician and programmer, to analyze, program, and code.

The first preliminary program ran in April, 1959, and showed a surprising degree of success, but also some "stupid" or "deaf" replies. The second preliminary program ran in August, 1959, and was a good deal more satisfactory; but this program also contains some undesirable responses for such reasons as failure to recognize certain English idioms, and incompleteness of syntactical analysis. . . .

3. Some Final Remarks by E. C. Berkeley

I think that this experiment with an automatic computer provides convincing evidence for some very important propositions about computers and about ideas. I will now state these propositions:

1. Theorem: A computer can operate reasonably with ideas.

2. Theorem: An idea for computer purposes is a specification of the meaning of a word or string of words.

3. Theorem: This specification of meaning can very often but not always be represented with a pair of symbols, one standing for a parameter such as "weather" or "emotion" and the second standing for a value of the parameter such as "rain" or "dislike."

After all, computers have been operating with ideas in the field of mathematics at least. Perhaps then we should not be too much surprised if a computer is also able to operate with ideas in all fields that can be talked about in language.

I will now make two predictions:

Prediction 1: It will not be many years — I would estimate hardly more than ten years — before the operating of computers with ideas will be widespread.

Prediction 2: When computers do operate generally with ideas, it will be impossible for a human being in another room to tell whether he is conversing with a computer or with a human being.

POSTSCRIPTS ON COMPUTERS AND AUTOMATION

From Walter Buckingham, *Automation* (New York, Harper & Brothers, 1961)

⊙ When looms weave by themselves man's slavery will end. — *Aristotle*

⊙ I can't understand it. I can't even understand the people who can understand it. — *Queen Juliana of the Netherlands (watching a demonstration of an electronic computer at an Amsterdam exhibition)*

⊙ We can lick gravity but sometimes the paperwork is overwhelming. — *Wernher von Braun*

⊙ Automation will stand or fall on the economic yardstick of cost versus payoff.
— *Frank Shallenberger*

⊙ It is better to have half a million men working in the industry at good wages and high standards of living than it is to have a million working in poverty and degradation. — *John L. Lewis*

⊙ The economic problems posed by (automation) can be solved only by a combination of competitive pressure, business statesmanship and constructive public policy. — *Edwin G. Nourse*

⊙ As automation becomes more widespread, we will undoubtedly face the alternative of choosing between two high values, both of which may turn into disvalues by excess: comfort and leisure.
— *Reinhold Niebuhr*

⊙ There is an old saying that Spring comes when it is most needed. The same can be said of automation. Automation is a logical consequence of preceding conditions. It is also bursting forth at the time when other scientific, technological, and organizational innovations are simultaneously springing up. — *Walter Buckingham*

⊙ I can't understand why you keep fretting, John. Automation or no automation, there will always be a chairman of the board. — *Caption under a* New Yorker *cartoon depicting a wife talking to her husband.*

⊙ I doesn't do much good to try to convince an individual worker that over a 25 years' span there is no such thing as technological unemployment. He doesn't care whether there is or not. All he is worried about is that he lost a job. — *Don Mitchell*

⊙ About 7 per cent of all office work in the United States is now done by automatic machines, according to IBM — who hopes to see 35 per cent automated in the foreseeable future. *Fortune* calls this "the coming victory over paper." — *Walter Buckingham*